IN THE DRAWINGS:

Please accept the 19 attached replacement sheets containing all the drawings of the application which have been rendered by a qualified draftsperson and are believed to be formal and acceptable.

REMARKS:

Claims 1-4, 7, 15, 18, 20-27, 31-33, 36-40, 42, 43, 50-54, 69-83, and 85 are in the case and presented for consideration.

The independent claims have been amended as follows:

Claim 1 has been amended to include in paragraph (g) a clear indication that the insulation layer clads the inner surface of the enlarged planar front panel shown for example at insulation layer 144 which clads the inner surface of the broad flat metal panel portion 119 of each wall panel. Claim 1 has also been amended to define the staggered rows of slits best shown in Figs. 3 and 4, which retard the otherwise rapid heat transfer between inner and outer surfaces of the metal wall panels. Heat transfer would otherwise be a serious problem in view of the all metal construction of the panels.

Independent claim 18 has been amended to define the insulation layer cladding as well as the unique corner construction best shown in Fig. 33A, the elected species for the present application. This includes the inner and outer L-shaped panels and the two specialized panel portions, namely, the ending panel 143 and the starting panel 121. The starting panel has one Z-shaped portion for engaging an adjacent wall panel extending from the corner along one wall, while the ending panel 142 includes its own Z-shaped portion for connecting to an adjacent wall panel of the other wall that extends to the corner. Unlike the starting panel 121, however, the ending panel 142 includes a simplified "opposing edge portion extending into the corner". This is contrasted to the starting panel 121 which includes "an opposing flanged portion extending into the corner". Thus, the simplified edge portion is contrasted to the more complex flange portion as shown in Fig. 33A, which avoids interference between the flanged portions while still permitting a structurally elegant corner arrangement which, in combination with the L-shaped inner and outer panels, provide both secure structure and places where the inner veneer panels or wall boards 133 can be attached.

Independent claim 36 has been amended to include the rows of staggered slits that retard heat transfer but otherwise retains the other limitations of claim 36 as previously presented.

Independent claim 69 defines the specialized corner structure of Fig. 33A, as well as requiring the presence of the L-shaped drainage slot in the lower beams.

Turning to the Office Action, the Examiner has confirmed Applicant's election which is acceptable without traverse.

The Examiner has also objected to the drawings as being blurred and having other defects. Attached to this amendment, please find a full set of formal drawings all marked as replacement sheets which are believed to comply with all rules and statutory requirements for the drawings.

The Examiner has also rejected claims 1, 28 and 84 as being indefinite under 35 U.S.C. 112 and appropriate corrections have been made. In claim 1, the distinction between the wall panels and the corner panels has been made clear and claims 28 and 84 have been cancelled.

The Examiner has rejected all of the claims as being obvious from a combination of various references, including U.S. Patent 5,117,602 to Marschak. Before treating the prior art and its relationship to the claims is now presented in detail, it is noted that the Examiner has incorrectly identified element 51 shown, for example, in Fig. 1 of Marschak as being a veneer. In fact, element 51 as even better shown in Figs. 10 and 11, represent studs and not a broad board like structure meant to be defined by the word "veneer" in the claims. Further, claim 1 and certain additional claims now presented call for the presence of an insulation layer cladding the inner surface of the enlarged planar front panel, that is the broad metal portion of each metal wall panel. See the specification, for example, at page 13, starting on line 25. See now cancelled claim 16 for the concept of a metal panel "clad" with insulation as well. As shown in the attached test results conducted by the NAHB

Research Center on August 2006, this insulation cladding on the surface of the broad surface of the metal panel has contributed to drastically increasing the rigidity and strength of the panel and has been found to avoid what is referred to as an "oil canning" effect where the thin broad metal panels 119 waffle and vibrate like the bottom of an oil can. This drastically reduces the strength and rigidity of the panel. This has been found quite surprisingly and unexpectedly to be drastically reduced by cladding the surface of the panel with an insulation layer. This is also very different from the teaching of Marschak, which discloses the use of a conventional space between studs which is filled with conventional insulation and which, thus, provides no reinforcement.

The undersigned verifies that the FRO MAR Structural Panel System of the NAHB tests, in fact corresponds to the invention disclosed in the present application. The test relevant to the improved strength afforded by the clad insulation is shown at page 16 at section 7.3 entitled Panel Shear Load where strengths of almost 900 pounds per linear foot were achieved even with very thin 22 gauge sheet metal panels.

On page 10, paragraph 14 of the action, the Examiner has rejected claims 16 and 17 as being obvious from a combination of Marschak in view of U.S. Patent 2,186,310 to Hoefen, taken further in view of U.S. Patent 3,300,934 to Waizenhofer. As explained in Waizenhofer at column 3, starting at line 23, batts of insulation 33 fill in the cavity formed in the panels. The term "clad" in the claims is meant to indicate a bonding, adhesion or connection between the insulation layer and the surface of the metal panel, which is a fair definition of the term "clad", especially when used in connection with clad metal. No new matter has been added since the term clad is clearly present in both claims 16 and 17 and clearly intended by the more comprehensive description of the relevant structure at page 13, starting on line 25. Thus, even if one were to combine the teachings of Marschak (which has no veneer and or insulation that is clad to any surface of the panels) and Waizenhofer (which uses a batt or panel that fills in a space) the skilled artisan would still

fall short of reaching claim 1 in one obvious manner. Claim 1, however, further includes the heat retarding staggered slits. In connection with this structure, the Examiner has cited U.S. patent 3,956,998 to Bavétz, which the Examiner has combined with Marschak and Hoefen, in the rejection of claims 60 and 61 at page 17, line 21 of the Office Action. Considering, thus, the combination of Marschak, Hoefen, Bavétz and Waizenhofer, in order to reach claim 1 in an obvious manner, the skilled artisan must first decide that Marschak should be augmented in an obvious manner by applying a clad layer of insulation to the inside surface of the broad metal part of the panel, despite Waizenhofer teaching of simply filling in a space. This insulation filling teaching simply augments what Marschak already says about filling the space with insulation. The skilled artisan must then decide that a corner structure as taught by Hoefen should be included and, further, that the staggered slits of Bavétz are appropriate. It is noted that the Bavétz reference deals with furnaces and specifically the problem of thermally separating inner and outer metal panels of the furnace wall, which must be connected by a strong U-shaped metal channel, but which would therefore suffer from fast heat transfer across this channel. To solve this problem, Bavétz provides slits (and specifically not slots) in the U-shaped channel (see column 2, lines 14-18 of the reference). Again, this is in the environment of a furnace, which anticipates furnace like temperatures as opposed to a building which must only experience temperature differences. The skilled artisan is then asked to apply technology from a different field (furnaces for Bavétz as opposed to buildings of the other 3 references) and then combine these with the other features of claim 1 in an obvious manner.

In the references of Marschak and Waizenhofer, the question of temperature differential is satisfied by filling a space with insulation. In Bavétz there is a dead space provided in the wall, which may or may not include refractory material, but which relies primarily on the slits in the channels to retard heat transfer. The skilled artisan must decide that for some reason the insulation of Waizenhofer and Marschak should be enhanced

further by treating any heat loss through the flanged portions and turn to Bavétz for this teaching. This combination is believed to be unobvious under 35 U.S.C. 103 and claim 1 is, therefore, believed to be patentable. None of the references mention the possibility an insulation layer which is clad to the metal panel would do anything other than heat insulation, whereas the present inventor has learned that the insulation not only improves heat transfer characteristics, but also improves the strength and effectiveness of the metal panels as building components to avoid the oil canning problem. This is certainly beyond the realm of obviousness and further evidences the patentability of claim 1.

The foregoing arguments are also relevant with respect to claim 18, to the extent that claim 18 defines the insulation layer cladding the inner surface of the broad metal portion of the wall panel. Claim 18 further defines the multi-part corner structure. It is noted that the Hoefen reference while showing a corner panel at Fig. 4, for example, does not include separate starting and ending panels each with their own characteristics as called for in claim 18, but rather a single bent metal structure forming the 90 degree angle. This would make it very difficult to accommodate walls which have any lengths other than an integral number of panel lengths. Otherwise, customized panels must be created for each wall dimension, other than the standard dimensions. According to the present invention, and as best shown in Fig. 33A, by using one starting panel 121, which can be of standard size and one ending panel 142, which can be produced of different lengths in an easy manner, only one small component of the overall corner must be changed to accommodate any wall length, even if it is not an exact integral number of panel widths. The skilled artisan, thus, has no teaching in any of the references and, in particularly not from Hoefen, on how to produce the combination of claim 18, particularly with respect to the corner structure. Accordingly, claim 18 is also believed patentable over the prior art and in condition for allowance.

Claim 36 includes the staggered rows of slits or slots for retarding heat transfer and

combines these with at least one corner comprising a pair of vertically extending members, including a starting corner panel and an ending panel of different construction from the starting corner panel. The heat transfer effect is, thus, achieved in claim 36 along with the ability to customize each corner in a manner which is believed to be unobvious and patentable over the prior art.

Claim 69 is believed to be clearly patentable over the prior art in its definition of the unique corner construction of the present invention, as well as, the presence of an L-shaped slot in the outer-flanged of the lower longitudinal beam which produces a drainage path for water that would otherwise accumulate in the lower channel and cause problems of corrosion, since there would be no place for the water to leave the structure. The Examiner's rejection on page 23, paragraph 26 is, thus, relevant in that claim 84, which had discussed a similar drainage slot had been rejected as obvious from a combination of Marschak, U.S. Patent 3,568, 388 to Flachbarth, taken further with Bavétz. The Examiner does not discuss the Flachbarth reference in particular, but this reference does show lower longitudinal beams with outer flanges having slots therein which would have a drainage effect. These slots, however, do not also extend into the web to enhance the drainage feature and even if the Hoefen reference were to be relied upon, the specialized corner structure called for in claim 68 is clearly missing from any combination of the prior art.

Accordingly, the independent claims are believed to be clearly patentable over the cited references and in condition for allowance.

The dependent claims, in particular, amended claims 3, 7, 15, 37, 39 and 40, which have been amended to even further distinguish the invention over the prior art are believed patentable as are the remaining claims which further distinguish the invention over the references.

By this amendment, thus, the application and claims are believed to be in condition for allowance.

No new matter has been added.

If any issues remain, the Examiner is respectfully invited to contact the undersigned at the number below, to advance the application to allowance.

Favorable action is respectfully requested.

Dated: February 8, 2007

Respectfully submitted,

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PCM:df

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TESTING OF FRO MAR® STRUCTURAL PANEL SYSTEM

Prepared For

Safe Guard Steel Building Systems LLC

Prepared By

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August 2006

NAHB RESEARCH CENTER *America's Housing Technology and Information Resource*

NAHB RESEARCH CENTER

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1. INTRODUCTION

The NAHB Research Center, Inc. (Research Center) personnel have conducted a testing evaluation for Safe Guard Steel Building Systems LLC (Safe Guard) of their Fro Mar Structural Panel System, including the panel, headers, and tracks. The evaluation was carried out in accordance with the following standards:

- ASTM E72-02, *Standard Test Methods of Conducting Strength Tests of Panels for Building Construction*
- ASTM E564-06, *Standard Practice for Static Load Test for Shear Resistance of Framed Walls for Buildings*
- ASTM E1996-05b, *Standard Specification for Performance of Exterior Windows, Curtain Walls, Doors and Impact Protective Systems Impacted by Windborne Debris in Hurricanes,*
- ASTM E1886-05, *Standard Test Method for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials.*

This testing was conducted in June, July and August 2006.

2. MATERIAL

Safe Guard submitted several crates of the Fro Mar Panel System and its components to our facility on June 2006. The test specimens were identified as follows:

Table 1 – Panel Specimens

Test Group No.	No. Of Panels	Panel Thickness	Panel Height	Steel Thickness
1 (axial)	24	3.5" & 5.5"	8 & 10 feet	22 & 18 Gauge
2 (bending)	24	3.5" & 5.5"	8 & 10 feet	22 & 18 Gauge
3 (shear)	10	3.5"	8 feet	22 & 18 Gauge
6 (impact)	3	3.5"	8 feet	22 & 20 Gauge

Table 2 – Header and Track Specimens

Test No.	No. Of Specimens	Header Length	Track Thickness	Steel Thickness
4 (header)	6	6-feet	-	18 & 14 Gauge
5 (tracks)	24	-	18, 16 & 14 Gauge	22 & 18 Gauge

Each individual panel measures 19.2" in width and is made from galvanized steel. The panel is formed or press-braked to shape and fastened to top and bottom tracks using 10-16

Phillips screws. Each Fro Mar panel consists of a wall panel in which the ribs of the wall panel are formed into stiffeners that effectively serve as load bearing studs in the system. Each panel connects to the next panel using a special interlocking stud on each end of the panel face. See Figure A1 for panel shape.

All steel used in the fabrication of the panel specimens, headers, and tracks are 33 ksi for 18 gauge, 20 gauge and 22 gauge steels, and 50 ksi for thicker steels.

3. TEST MATRIX

The following test matrix lists all tests performed in this report.

Table 3 – Axial Tests (Gravity Loads)

Panel Size	Panel Thickness	Panel Height	Steel Strength	Steel Thickness	No. Of Tests
2 pcs-19.2"	3.5"	8 feet	33 ksi	22 Gauge	3
2 pcs-19.2"	3.5"	8 feet	33 ksi	18 Gauge	3
2 pcs-19.2"	3.5"	10 feet	33 ksi	22 Gauge	3
2 pcs-19.2"	3.5"	10 feet	33 ksi	18 Gauge	3
2 pcs-19.2"	5.5"	8 feet	33 ksi	22 Gauge	3
2 pcs-19.2"	5.5"	8 feet	33 ksi	18 Gauge	3
2 pcs-19.2"	5.5"	10 feet	33 ksi	22 Gauge	3
2 pcs-19.2"	5.5"	10 feet	33 ksi	18 Gauge	3

Table 4 – Bending Tests

Panel Size[1]	Panel Thickness	Panel Height	Steel Strength	Steel Thickness	No. Of Tests
2 pcs-19.2"	3.5"	8 feet	33 ksi	22 Gauge	3
2 pcs-19.2"	3.5"	8 feet	33 ksi	18 Gauge	3
2 pcs-19.2"	3.5"	10 feet	33 ksi	22 Gauge	3
2 pcs-19.2"	3.5"	10 feet	33 ksi	18 Gauge	3
2 pcs-19.2"	5.5"	8 feet	33 ksi	22 Gauge	3
2 pcs-19.2"	5.5"	8 feet	33 ksi	18 Gauge	3
2 pcs-19.2"	5.5"	10 feet	33 ksi	22 Gauge	3
2 pcs-19.2"	5.5"	10 feet	33 ksi	18 Gauge	3

[1] All panels have ½" GWB on interior side fastened with #6 drywall screws at 12" on center..

Table 5 – Racking Shear Tests (Monotonic and Cyclic)

Panels[1,2,3]	Test Configuration	Panel Thickness	Panel Height	Steel Strength	Steel Thickness	No. Of Tests
5 pcs-19.2"	Monotonic	3.5"	8 feet	33 ksi	22 Gauge	2
5 pcs-19.2"	Monotonic	3.5"	8 feet	33 ksi	18 Gauge	2
5 pcs-19.2"	Cyclic	3.5"	8 feet	33 ksi	22 Gauge	2
5 pcs-19.2"	Cyclic	3.5"	8 feet	33 ksi	18 Gauge	2

[1] All panels were fabricated with 1" foam glued to the inside face of the panels.
[2] All panels have 18 gauge top and bottom tracks.
[3] All panels have service knockouts.

Table 6 – Header Assembly Tests

Header Size	Steel Strength	Header Thickness	Header Depth	Steel Thickness	No. Of Tests
6 feet	33 ksi	3.5"	10"	18 Gauge	3
6 feet	50 ksi	3.5"	10"	14 Gauge	3

[1] Two-point loading test for each simply supported header assembly.

Table 7 – Top Track Point Load Tests

Track Size	Wall Thickness	Track Thickness	Steel Strength	Panel Steel Thickness	Panel Steel Strength	No. Of Tests
2.5"x3.5"x1.5"	3.5"	18 Gauge	33 ksi	22 Gauge	33 ksi	3
3.5"x3.5"x2.5"	3.5"	16 Gauge	50 ksi	22 Gauge	33 ksi	3
3.5"x3.5"x2.5"	3.5"	16 Gauge	50 ksi	18 Gauge	33 ksi	3
4"x3.5"x3.5"	3.5"	14 Gauge	50 ksi	18 Gauge	33 ksi	3
2.5"x5.5"x1.5"	5.5"	18 Gauge	33 ksi	22 Gauge	33 ksi	3
3.5"x5.5"x2.5"	5.5"	16 Gauge	50 ksi	22 Gauge	33 ksi	3
3.5"x5.5"x2.5"	5.5"	16 Gauge	50 ksi	18 Gauge	33 ksi	3
4"x5.5"x3.5"	5.5"	14 Gauge	50 ksi	18 Gauge	33 ksi	3

Table 8 – Missile Impact Test

Panel Size	Panel Thickness	Steel Strength	Steel Thickness	No. Of Tests
1 pc-19.2"	3.5"	33 ksi	22 Gauge	3
1 pc-19.2"	3.5"	33 ksi	20 Gauge	3

[1] All panels were fabricated with 1" foam adhered to the inside of the panels.

4. TEST PROCEDURE

4.1 Conditioning

Before testing, fabricated specimens were held in standard laboratory conditions for at least 40 hours at a temperature of 23 ± 2°C and relative humidity of 50 ± 5%.

4.2 Axial Load Tests

Three walls of each configuration (i.e., panel thickness, steel thickness, and height) were loaded in increments to failure in accordance with ASTM E72-02, Section 9. An axial force was applied to the walls uniformly along a line parallel to the inside face, and one-third the thickness of the product from the inside face. The axial force was applied using a 200,000 lb universal testing machine (UTM, Southwark-Emery Model 78075). To measure lateral movement, a Satek Epsilon Series 2-inch deflectometer was attached to a clamp near the upper end on each vertical edge of the specimen. The deflection readings were recorded using a Newvision II Data Acquisition System for each test to establish deformation and set characteristics for compressive and lateral movement. The walls were loaded at a rate to achieve the incremental loads between 10 seconds and 5 minutes. The incremental test loads were held for five minutes before the load was released.

4.3 Transverse (Bending) Tests

A steel reaction frame capable of supporting the wall panels was used for testing. The inside length and width of the frame was slightly larger than the wall systems to allow for free downward movement during testing. Walls were erected horizontally in the frame and rested on a bottom roller to eliminate friction from the bottom edge. The walls were simply supported at each end on 2-in. diameter steel rollers. The walls were instrumented with deflection gauges to monitor deformation during loading. The deflection gauges were located at the centre of the outer studs and one gauge at centre point on the panel. All deflection measurements were made from a reference point independent of the test specimens. The test specimens were loaded using the two-point beam method as specified in ASTM E72-04, Section 11.3.1. Load was applied using a 20-ton hydraulic pump. The test setup and loading procedure for the panels are represented in Figure 2.

4.4 Racking Shear Tests

4.4.1 Monotonic Tests

Three walls of each configuration were loaded in increments to failure as per ASTM E 564-06. A minimum of six deflection readings were recorded at

predefined loads in order to establish deformation and set characteristics for the walls. The predefined loads were achieved within a period of between 10 seconds and 5 minutes. The loads were held for five minutes or until equilibrium was reached. Equilibrium was defined as no deflection changes before the load was released. Deflection gauges were located to monitor base slip, uplift, top plate horizontal displacement, and vertical displacement. Racking loads were applied parallel to and at the top centre of the panel. The racking loads were accomplished using a hydraulic ram assembly and monitored using a load cell. The loads were held for five minutes or until equilibrium was reached. Equilibrium was defined as no deflection changes before the load was released. Specimen characteristics are summarized in Table 9. See Figure A3 for test configuration.

4.4.2 Cyclic Tests

The tests were performed according to the general provisions of ASTM Standard E2126 *Standard Test Methods for Cyclic (Reversed) Load Test for Shear Resistance of Walls for Buildings*. The wall panels were tested cyclically in accordance with the ASTM E2126 protocol using delta of 1.5 inches and frequency of 20 Hz. The wall configuration was tested twice for repeatability in accordance with the ASTM standard.

The wall panels were installed in accordance with manufacturer's specifications. Corners of each wall specimen were restrained with a Simpson Strong-Tie HTT16 hold-down. Specimen characteristics are summarized in Table 9. Figure A3.1 shows a typical schematic of a cyclic test.

The tests were performed using a racking shear apparatus. Cylinder motion was controlled using a computer-based system. Load was measured using a 50,000 lb electronic load cell. Wall assembly drift was measured using a string potentiometer. Specimen uplift, slip, and compressive deformation were measured using Linear Variable Differential Transformers (LVDTs). Load and displacement readings were recorded using a digital data acquisition system at a frequency of 20 Hz such that at least 100 data points were gathered for each cycle. All instruments were calibrated in accordance with the NAHB Research Center Laboratory Quality Manual.

Table 9 – Wall Specimen Characteristics

Fro Mar Panels	
Framing Component	**Description**
Wall Panel Length	8 Feet
Individual Panel Width	19.2"
No. of Panels	5
Nominal Panel Thickness	3.5"
Openings	None
Steel Thickness	22 and 18 Gauge
Framing Screws	#10x16 Phillips
Other Attachments	1" Thick foam board glued to inside of each panel
Gusset Plates	Gusset plates were fastened to bottom corners of most panels using #10x16 Phillips screws @ 6" o.c.
Anchorage	½-inch bolts with round cut washers spaced 4 feet on center
Hold-down at corners	Simpson Strong-Tie HTT16 attached with #10 screws; Hold-down raised about 1" from the sill plate

4.5 Header Tests

Testing was conducted in accordance with ASTM E72-06 and ASTM D198. Load and deflection data were continuously recorded until failure.

The header assemblies were tested using a 200,000 lb universal testing machine (UTM, Southwark-Emery Model 78075), a Satek Epsilon Series 2 inch deflectometer, and a Newvision II Data Acquisition System. Third point loading (two-point loading) was used as illustrated in Figure A4. The load was applied at a load rate of 1/10 inch per minute until the headers failed. Failure constitutes failure of the header material (buckling, bearing or crippling) or failure of the screws (shear or pull out). Deflections at the midpoint of the headers were recorded during the full range of loads using linear variable differential transformers (LVDTs).

4.6 Top Track Point Load Test

Track specimens were tested using a 200,000 lb universal testing machine (UTM, Southwark-Emery Model 78075), a Satek Epsilon Series 2 inch deflectometer, and a Newvision II Data Acquisition System. Load was applied at the center of the track as illustrated in Figure A5. The load was applied at a load rate of 1/10 inch per minute until the track failed. Failure constitutes failure of the track material (buckling, bearing or crippling) or failure of the screws (shear or pull out). Deflections at the midpoint of the

tracks were recorded during the full range of loads using linear variable differential transformers (LVDTs).

4.7 Missile Impact Test

Three specimens for each panel thickness were tested to ASTM E1886/E1996 for the conditions shown in Table 1. This testing involved impacting the specimen with the large missile. All specimens were tested with the large missile impact targeted at the center of the panels, and within 6" of the top and bottom corners.

The test protocol specified in ASTM E1886 and ASTM E1996 calls for impacting the panels with a large missile at a velocity of 50 ft/sec. An 8-foot long southern yellow pine 2x4 weighing 4100 grams (+/- 100 g) was used as the large missile. The air cannon apparatus shown in Figure A6 used compressed air to propel the missile. A pair of light sensors was used to time the missile as it left the air cannon barrel. The velocity of the missile was calculated based on distance between the sensors and the elapsed time. The timer was calibrated prior to testing and velocity was verified per ASTM E1886 Section 9.1.3. The size of the missile penetration was examined to make sure that a 3" diameter sphere would not be able to pass through the hole. Table 10 lists the parameters for the impact tests. See Figure A6 (Appendix A) for photo of test assembly.

Table 10 – Fro Mar Panels Impact Test Parameters

Panel Size	Large Missile Velocity	Wind Zone	Protection Level	Missile Type
19.2" x 3.5" x 22 Gauge	50 fps	4	Basic	D
19.2" x 3.5" x 20 Gauge	50 fps	4	Basic	D

4.8 Steel Coupon Tests

Tensile and yield strengths were verified by tensile tests in accordance with ASTM A370 *Standard Test Methods and Definitions for Mechanical Testing of Steel Product*. Base steel thickness was also established and measured in accordance with ASTM A90 *Standard Test Method of Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings*. Mechanical properties were based on coupons cut from the center of the web from a sample of the test specimens.

5. TEST RESULTS

5.1 Axial Tests

Axial test results for the Fro Mar Panel specimens are tabulated in Table 11 to which no

safety factor has been applied.

Table 11 – Axial Load Test Results

Test No.	Panel Thickness	Panel Height	Steel Strength	Steel Thickness	Peak Load
1	3.5"	8 feet	33 ksi	22 Gauge	9,670
2	3.5"	8 feet	33 ksi	22 Gauge	9,796
3	3.5"	8 feet	33 ksi	22 Gauge	9,376
4	3.5"	8 feet	33 ksi	18 Gauge	27,738
5	3.5"	8 feet	33 ksi	18 Gauge	29,637
6	3.5"	8 feet	33 ksi	18 Gauge	29,172
7	3.5"	10 feet	33 ksi	22 Gauge	12,787
8	3.5"	10 feet	33 ksi	22 Gauge	11,870
9	3.5"	10 feet	33 ksi	22 Gauge	11,338
10	3.5"	10 feet	33 ksi	18 Gauge	28,596
11	3.5"	10 feet	33 ksi	18 Gauge	28,768
12	3.5"	10 feet	33 ksi	18 Gauge	30,823
13	5.5"	8 feet	33 ksi	22 Gauge	9,881
14	5.5"	8 feet	33 ksi	22 Gauge	9,923
15	5.5"	8 feet	33 ksi	22 Gauge	9,444
16	5.5"	8 feet	33 ksi	18 Gauge	29,322
17	5.5"	8 feet	33 ksi	18 Gauge	28,471
18	5.5"	8 feet	33 ksi	18 Gauge	28,587
19	5.5"	10 feet	33 ksi	22 Gauge	12,703
20	5.5"	10 feet	33 ksi	22 Gauge	11,123
21	5.5"	10 feet	33 ksi	22 Gauge	11,334
22	5.5"	10 feet	33 ksi	18 Gauge	26,721
23	5.5"	10 feet	33 ksi	18 Gauge	26,337
24	5.5"	10 feet	33 ksi	18 Gauge	28,495

5.2 Transverse Tests

Bending test results for the Fro Mar Panel specimens are tabulated in Table 12 to which no safety factor has been applied

Table 12 – Bending Load Test Results

Test No.	Panel Thickness	Panel Height	Steel Strength	Steel Thickness	Peak Load (lb)
1	3.5"	8 feet	33 ksi	22 Gauge	3,109
2	3.5"	8 feet	33 ksi	22 Gauge	3,244
3	3.5"	8 feet	33 ksi	22 Gauge	3,245
4	3.5"	8 feet	33 ksi	18 Gauge	8,254
5	3.5"	8 feet	33 ksi	18 Gauge	8,255
6	3.5"	8 feet	33 ksi	18 Gauge	8,255
7	3.5"	10 feet	33 ksi	22 Gauge	2,566
8	3.5"	10 feet	33 ksi	22 Gauge	2,702
9	3.5"	10 feet	33 ksi	22 Gauge	2,838
10	3.5"	10 feet	33 ksi	18 Gauge	6,494
11	3.5"	10 feet	33 ksi	18 Gauge	6,629
12	3.5"	10 feet	33 ksi	18 Gauge	6,495
13	5.5"	8 feet	33 ksi	22 Gauge	4,192
14	5.5"	8 feet	33 ksi	22 Gauge	4,192
15	5.5"	8 feet	33 ksi	22 Gauge	4,327
16	5.5"	8 feet	33 ksi	18 Gauge	11,369
17	5.5"	8 feet	33 ksi	18 Gauge	11,640
18	5.5"	8 feet	33 ksi	18 Gauge	10,693
19	5.5"	10 feet	33 ksi	22 Gauge	3,892
20	5.5"	10 feet	33 ksi	22 Gauge	3,977
21	5.5"	10 feet	33 ksi	22 Gauge	3,842
22	5.5"	10 feet	33 ksi	18 Gauge	8,905
23	5.5"	10 feet	33 ksi	18 Gauge	8,932
24	5.5"	10 feet	33 ksi	18 Gauge	8,661

5.3 Racking Shear Tests

5.3.1 Monotonic Tests

Table 13 summarizes the results of the monotonic racking shear tests to which no safety factor has been applied.

Table 13 – Monotonic Test Results

Test No.	Panel Thickness	Panel Height	Panel Width	Steel Thickness	Perimeter Screws	Corner Gusset	Peak Shear Load (lb)
1	3.5"	8 feet	8 feet	22 Gauge	12" o.c.	No	5,817
2	3.5"	8 feet	8 feet	22 Gauge	6" o.c.	No	6,638
3	3.5"	8 feet	8 feet	22 Gauge	6" o.c.	Yes	7,454
4	3.5"	8 feet	8 feet	22 Gauge	6" o.c.	Yes	6,881
5	3.5"	8 feet	8 feet	18 Gauge	6" o.c.	Yes	14,025
6	3.5"	8 feet	8 feet	18 Gauge	6" o.c.	Yes	14,083

5.3.2 Cyclic Tests

Table 14 summarizes the results of the cyclic racking shear tests to which no safety factor has been applied.

Table 14 – Cyclic Test Results

Test No.	Panel Thickness	Panel Height	Panel Width	Steel Thickness	Perimeter Screws	Corner Gusset	Peak Shear Load [1] (lb)
1	3.5"	8 feet	8 feet	22 Gauge	6" o.c.	Yes	7,039
2	3.5"	8 feet	8 feet	22 Gauge	6" o.c.	Yes	7,273
3	3.5"	8 feet	8 feet	18 Gauge	6" o.c.	Yes	12,312
4	3.5"	8 feet	8 feet	18 Gauge	6" o.c.	Yes	13,143

[1] Average value is calculated by summing up the peak negative and positive values and dividing by 2.

5.4 Header Tests

Test results for the header specimens are tabulated in Table 15 to which no safety factor has been applied. The typical failure mode for all tests was the buckling of the sheet steel under the point load.

Table 15 – Header Test Results

Test No.	Header Clear Span	Steel Strength	Steel Thickness	Header Depth (in)	Header Width (in)	Peak Load (lb)	Peak Deflection (in)
1	6 feet	33 ksi	18 Gauge	10	3.5	9,362	0.6483
2	6 feet	33 ksi	18 Gauge	10	3.5	8,832	0.6384
3	6 feet	33 ksi	18 Gauge	10	3.5	8,755	0.5504
4	6 feet	50 ksi	14 Gauge	10	3.5	19,004	0.8045
5	6 feet	50 ksi	14 Gauge	10	3.5	20,732	0.9305
6	6 feet	50 ksi	14 Gauge	10	3.5	20,586	0.7558
7	6 feet	33 ksi	18 Gauge	10	3.5	9,394	0.5848
8	6 feet	50 ksi	14 Gauge	10	3.5	20,356	0.6661

5.5 Track Tests

Test results for the track specimens are tabulated in Table 16 to which no safety factor has been applied.

Table 16 – Track Bending Test Results

Test No.	Track Size	Track Depth	Track Thickness	Steel Yield	Panel Steel Thickness	Peak Load (lb)
1	2.5"x3.5"x1.5"	3.5"	18 Gauge	33 ksi	22 Gauge	2,175
2	2.5"x3.5"x1.5"	3.5"	18 Gauge	33 ksi	22 Gauge	2,239
3	2.5"x3.5"x1.5"	3.5"	18 Gauge	33 ksi	22 Gauge	2,189
4	3.5"x3.5"x2.5"	3.5"	16 Gauge	50 ksi	22 Gauge	4,031
5	3.5"x3.5"x2.5"	3.5"	16 Gauge	50 ksi	22 Gauge	3,987
6	3.5"x3.5"x2.5"	3.5"	16 Gauge	50 ksi	22 Gauge	4,381
7	3.5"x3.5"x2.5"	3.5"	16 Gauge	50 ksi	18 Gauge	6,280
8	3.5"x3.5"x2.5"	3.5"	16 Gauge	50 ksi	18 Gauge	5,715
9	3.5"x3.5"x2.5"	3.5"	16 Gauge	50 ksi	18 Gauge	5,604
10	4"x3.5"x3.5"	3.5"	14 Gauge	50 ksi	18 Gauge	10,659
11	4"x3.5"x3.5"	3.5"	14 Gauge	50 ksi	18 Gauge	9,436
12	4"x3.5"x3.5"	3.5"	14 Gauge	50 ksi	18 Gauge	9,646
13	2.5"x3.5"x1.5"	5.5"	18 Gauge	33 ksi	22 Gauge	2,359
14	2.5"x3.5"x1.5"	5.5"	18 Gauge	33 ksi	22 Gauge	2,182
15	2.5"x3.5"x1.5"	5.5"	18 Gauge	33 ksi	22 Gauge	2,176

Table 16 – Track Bending Test Results (continued)

Test No.	Track Size	Track Depth	Track Thickness	Steel Yield	Panel Steel Thickness	Peak Load (lb)
16	3.5"x3.5"x2.5"	5.5"	16 Gauge	50 ksi	22 Gauge	4,395
17	3.5"x3.5"x2.5"	5.5"	16 Gauge	50 ksi	22 Gauge	4,330
18	3.5"x3.5"x2.5"	5.5"	16 Gauge	50 ksi	22 Gauge	4,418
19	3.5"x3.5"x2.5"	5.5"	16 Gauge	50 ksi	18 Gauge	5,338
20	3.5"x3.5"x2.5"	5.5"	16 Gauge	50 ksi	18 Gauge	5,358
21	3.5"x3.5"x2.5"	5.5"	16 Gauge	50 ksi	18 Gauge	5,363
22	4"x3.5"x3.5"	5.5"	14 Gauge	50 ksi	18 Gauge	9,463
23	4"x3.5"x3.5"	5.5"	14 Gauge	50 ksi	18 Gauge	9,098
24	4"x3.5"x3.5"	5.5"	14 Gauge	50 ksi	18 Gauge	9,242

5.6 Missile Impact Tests

Test results for the missile impact tests are shown in Table 17. Impacting each panel at the center did not cause any tear out or any damage to the panel. However, the second missile impacting each panel within 6" of the top or bottom corners of the panels caused the screws closest to the impact point to tear out of the track after the missile impact. The panel at the impacted point was badly damaged but did not have any tears or holes.

Table 17 – Missile Impact Test Results

Test No.	Panel Size	Panel Thickness	Steel Thickness	Panel Height	Steel Yield	Missile Penetrated Panel	Panel Tear[1]
1	19.2"	3.5"	22 Gauge	8-feet	33 ksi	No	No
2	19.2"	3.5"	22 Gauge	8-feet	33 ksi	No	No
3	19.2"	3.5"	22 Gauge	8-feet	33 ksi	No	No
4	19.2"	3.5"	20 Gauge	8-feet	33 ksi	No	No
5	19.2"	3.5"	20 Gauge	8-feet	33 ksi	No	No
6	19.2"	3.5"	20 Gauge	8-feet	33 ksi	No	No

[1] All panel specimens tested had few screws pulled out of the track after the missile impacted the panel within 6" of the corners. No tear out in the panel observed.

5.7 Coupon Tests

Coupon test results are shown in Table 18.

Table 18 – Mechanical Properties of Steel

Steel Thickness	Yield Point[1] (psi)	Tensile Strength[1] (psi)	Uncoated Thickness[2] (in.)	Elongation[3] (percent)
22 Gauge	34,850	45,100	0.02699	20.2
	36,710	45,850	0.02710	20.3
	35,570	47,430	0.02694	19.9
18 Gauge	36,500	46,610	0.04590	22.5
	37,550	45,800	0.04512	21.5
	35,220	47,040	0.04620	22.1
16 Gauge	52,108	67,800	0.05392	21.9
	51,900	68,200	0.05398	20.5
	53,400	68,020	0.05395	20.3
14 Gauge	53,250	66,350	0.06782	19.8
	54,600	67,150	0.06786	21.7
	53,980	67,250	0.0780	20.2

[1] Yield point and tensile strength are actual yield point and tensile strength from coupons cut from the web of the angle specimen and tested per ASTM A370.
[2] Uncoated thickness is the base steel thickness of the steel as tested per ASTM A90.
[3] Tested in accordance with ASTM A370 for a two-inch gauge length.

6. SAFETY AND PHI FACTOR CALCULATIONS

Safety factors (Ω) or Resistance factors (ϕ) can be applied to the average ultimate capacity for each set of tests to determine the allowable strength or design strength, respectively. These factors are calculated in accordance with the AISI North *American Specification for the Design of Cold-Formed Steel Structures* (NASPEC 2001 Edition) as shown below. The Ω and ϕ factors for the shear strengths are specified in the AISI *Standard for Cold-Formed Steel Framing – Lateral Design* (2004 Edition).

The strength of the tested assemblies shall satisfy the following equations:

$\sum \gamma_i Q_i \leq \phi R_n$ For LRFD
$\phi R_n \geq \gamma_i Q_i$ For ASD

Where:
R_n = Average value of the test results.
$\gamma_i Q_i$ Required strength based on the most critical load combination.
ϕ = Resistance factor = $C_\phi (M_m F_m P_m) e^{-\beta_0 \sqrt{V^2_M + V^2_F + C_P V_P^2 + V^2_Q}}$
C_ϕ = 1.52 (Calibration Factor)
M_m = Mean value of the material factor = 1.10 (bending or compression)
F_m = Mean value of the fabrication factor = 1.00
P_m = Mean value of the professional factor for the tested component = 1.0
β_0 = Target reliability index = 2.5

V_M = Coefficient of variation of the material factor = 0.10 (bending or compression)
V_F = Coefficient of variation of the fabrication factor = 0.05
C_P = Correction factor = 5.7
V_P = Coefficient of variation of the test results (for V_P < 6.5%, use 6.5%)
V_Q = Coefficient of variation of the load effect = 0.21
$\Omega = \frac{1.6}{\phi}$

The following factors (Table 19) are calculated for the tests covered in this report.

Table 19 – Safety and Phi Factors

Specimen Description	Test Assembly	Safety Factor[1] Ω	Phi Factor[1] ϕ
• 3.5" and 5.5" thick • up to 10-foot high • 22, 20, and 18 gauge thick steel	Axial Tests	1.95	0.82
• 3.5" and 5.5" thick • up to 10-foot high • 22, 20, and 18 gauge thick steel	Bending Tests	1.95	0.82
• 3.5" and 5.5" thick • up to 10-foot high • 22, 20, and 18 gauge thick steel	Racking Shear	2.5 for seismic loads 2.0 for wind loads [2]	0.60 for seismic loads 0.65 for wind loads [2]
• 3.5" and 5.5" thick • up to 6-foot span • 18, 16, and 14 gauge thick steel • 10" deep headers	Header Tests	1.95	0.82
• 3.5" and 5.5" panels • up to 19.2" maximum width • 18, 16, and 14 gauge thick track thickness • 10" deep headers	Track Tests	1.95	0.82

[1] The highest COV was used in calculating the Ω and ϕ factors for each test configuration.
[2] Safety and phi factors are specified in AISI Lateral Design Standard.

7. SUMMARY

7.1 Panel Axial Capacity

Table 20 summarizes the average nominal axial load for the Fro Mar Panels tested with the applicable Ω and ϕ factors. The nominal load for the 9-foot and the 20-gauge panels were interpolated from the test results.

Table 20 – Average Nominal Panel Axial Capacity (lb)[1,2,3]

Panel Thickness (Gauge)	Panel Height: 8-Foot		9-Foot		10-Foot	
	Panel Thickness: 3.5"	5.5"	3.5"	5.5"	3.5"	5.5"
22	9614 (3004)	9749 (3046)	10806 (3377)	10735 (3355)	11998 (3749)	11720 (3663)
20	16821 (5256)	16885 (5277)	17669 (5521)	17200 (5375)	18517 (5787)	17514 (5473)
18	28849 (9015)	28793 (8998)	29123 (9101)	27989 (8747)	29396 (9186)	27184 (8495)

[1] Values in parenthesis are pounds per linear foot of wall.
[2] The 9-foot and 20 gauge panel capacities were interpolated from the average peak loads for 8-foot, 10-foot, 22 gauge and 18 gauge panels.
[3] For LRFD a "ϕ" factor of 0.82 shall be sued. For ASD a "Ω" factor of 1.95 shall be used.

7.2 Panel Bending Capacity

Table 21 summarizes the average nominal transverse (bending) load for the Fro Mar Panels tested with the applicable Ω and ϕ factors. The nominal load for the 9-foot and the 20-gauge panels were interpolated from the test results.

Table 21 – Average Nominal Panel Bending Capacity (lb)[1,2,3]

Panel Thickness (Gauge)	Panel Height: 8-Foot		9-Foot		10-Foot	
	Panel Thickness: 3.5"	5.5"	3.5"	5.5"	3.5"	5.5"
22	3,199 (125)	4,237 (165)	2,951 (100)	4,071 (140)	2,702 (95)	3,904 (135)
20	5,093 (200)	6,859 (270)	4,617 (160)	6,305 (245)	4,140 (145)	5,751 (200)
18	8,255 (320)	11,234 (440)	7,397 (255)	10,034 (350)	6,539 (225)	8,833 (305)

[1] Values in parenthesis are pounds per square foot (psf) of wall.
[2] The 9-foot and 20 gauge panel capacities were interpolated from the average peak loads for 8-foot, 10-foot, 22 gauge and 18 gauge panels.
[3] For LRFD a "ϕ" factor of 0.82 shall be used. For ASD a "Ω" factor of 1.95 shall be used.

7.3 Panel Shear Load

The nominal monotonic and cyclic shear values for the Fro Mar wall panels have been developed in this test report (see Table 22).

Table 22 – Average Nominal Unit Monotonic and Cyclic Shear Values

Panel Description	Panel Width	Fastener Type	Minimum Steel Thickness	Average Nominal Shear Value (lb)	Nominal Unit Shear Value (lb/ft)
Monotonic					
Fro Mar Panel System Wall Panel	3.5"	#10x16 Phillips Screws	22 Gauge	6,263	783
			22 Gauge	7,168 (1)	896
			20 Gauge	9,748 (1)(2)	1,218
			18 Gauge	14,054 (1)	1,757
Cyclic					
Fro Mar Panel System Wall Panel	3.5"	#10x16 Phillips Screws	22 Gauge	7,156 (1)	895
			20 Gauge	9,243 (1)	1,156
			18 Gauge	12,727 (1)	1,591

[1] Value for wall panel with gusset plates at bottom corners fastened with #10 screws at 6" o.c.
[2] Shear value obtained by interpolation.

7.4 Header Capacity

Table 23 summarizes the average nominal load for the headers tested with the applicable Ω and ϕ factors. The nominal load for the 16-gauge header thickness was interpolated from the test results.

Table 23 – Average Nominal Header Capacity (1)(2)

Header Clear Span	Steel Strength	Steel Thickness	Average Nominal Header Capacity	
			Pounds	Pounds per Foot (lb/ft)
6 feet	33 ksi	18 Gauge	8,983	1,497
6 feet	50 ksi	16 Gauge	13,877 (3)	2,313
6 feet	50 ksi	14 Gauge	20,107	3,351

[1] Headers can be assembled with screws or spot welds.
[2] For LRFD a "ϕ" factor of 0.82 shall be sued. For ASD a "Ω" factor of 1.95 shall be used.
[3] 54 mil (16-gauge) header peak load was interpolated from the average peak loads for 14 gauge and 18 gauge headers.

7.5 Track Capacity

Table 24 summarizes the average nominal point load for the tracks headers tested with the applicable Ω and ϕ factors.

Table 24 – Average Nominal Track Capacity[1,2] (lb)

Track Thickness	Panel Thickness	Track Size			
		2.5"x3.5"x1.5"	3.5"x3.5"x2.5"	3.5"x3.5"x2.5"	4.0"x3.5"x3.5"
18 Gauge	3.5"	2,201			
	5.5"	2,239			
16 Gauge	3.5"		4,133	5,886	
	5.5"		4,381	5,353	
14 Gauge	3.5"				9,914
	5.5"				9,268

[1] All track material shall have minimum F_Y of 50 ksi except for 18 gauge which has a F_Y of 33 ksi.
[2] For LRFD a "ϕ" factor of 0.82 shall be sued. For ASD a "Ω" factor of 1.95 shall be used.

7.6 Missile Impact Test

The 20 and 22 gauge thick Fro Mar panels met the requirements of ASTM E1996 for wind zone 4 for all building designated as basic protection for assembly elevations less than and greater than 30 feet. Table 25 summarizes the applicability of the missile impact test to the different wind speeds and levels of protection as defined in ASTM E1996-05b.

Table 25 – Fro Mar Panels Applicability

Wind Zone	Wind Speed (mph)	Enhanced Protection		Basic Protection		Unprotected	
		≤ 30 ft	> 30 ft	≤ 30 ft	> 30 ft	≤ 30 ft	> 30 ft
1	< 120	√	√	√	√	√	√
2	< 130	√	√	√	√	√	√
3	Between 130 & 140	-	√	√	√	√	√
4	> 140	-	√	√	√	√	√

8. UNCERTAINTY

The uncertainty of the peak load measurements has been estimated at 0.5 percent. The uncertainty of the displacement measurements has been estimated at 1.1 percent. These estimates were made using Type B analysis at a 95 percent confidence level with a coverage factor of k=2.

9. DECLARATIONS AND DISCLAIMERS

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Nader Elhajj, P.E.
Project Manager

Nader Elhajj August 14, 2006

Signature Date

Appendix A
Test Assemblies

Figure A1. Axial (Compression) Load Test Assembly

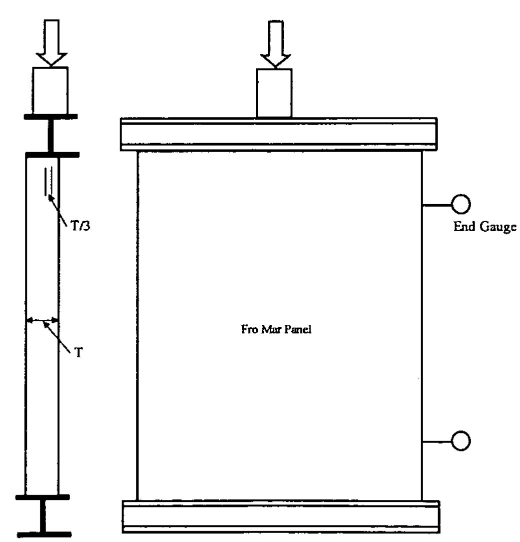


Figure A2. Transverse (Bending) Load Test Assembly

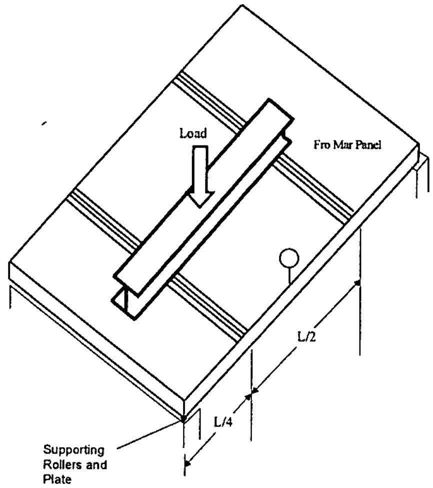


Figure A3. Monotonic Racking Shear Load Test Assembly

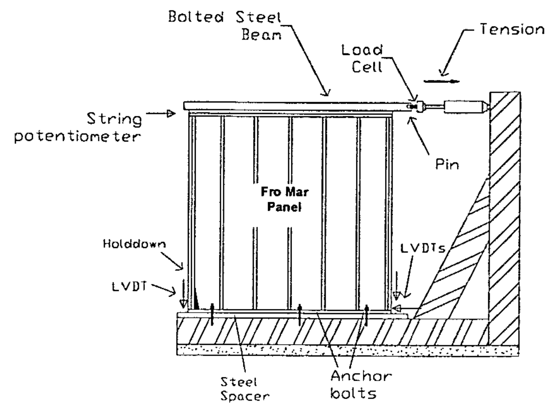


Figure A3.1 Typical Cyclic Shear Wall Test Set-Up

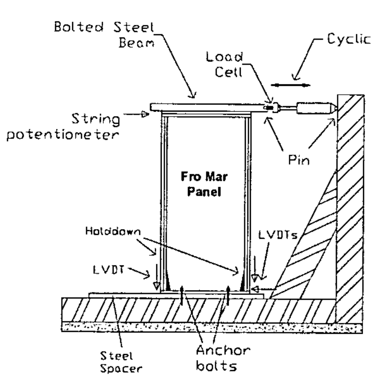


Figure A4. Header Test Assembly

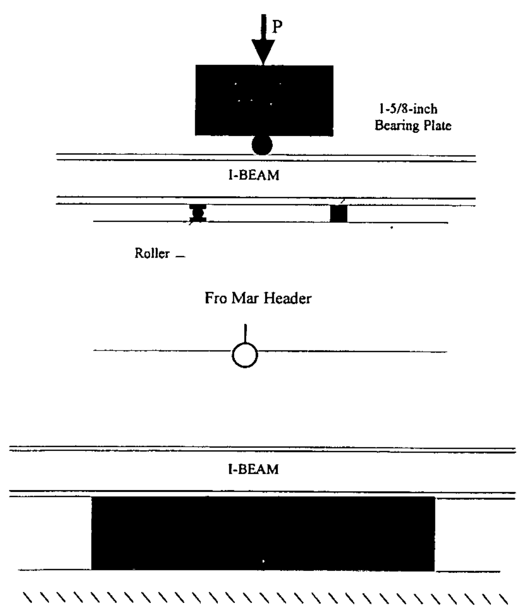


Figure A5. Track Test Assembly

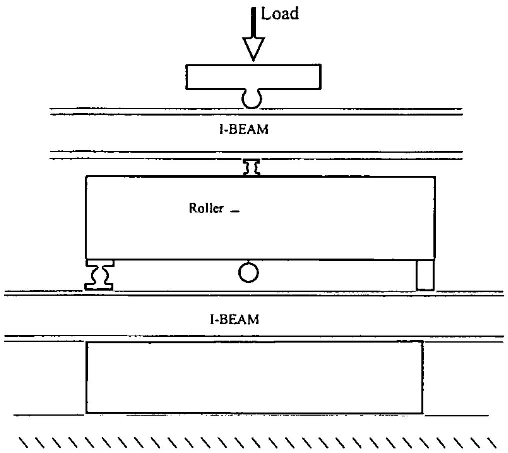
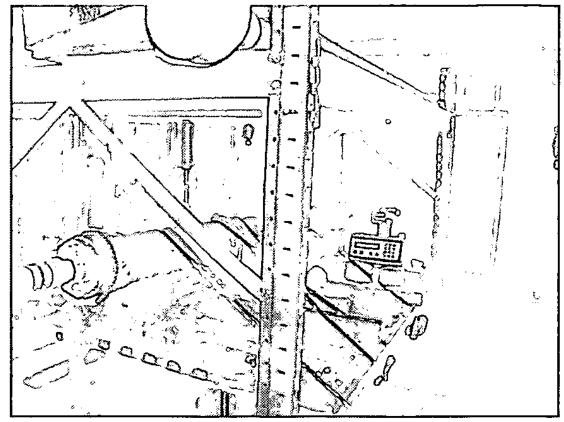
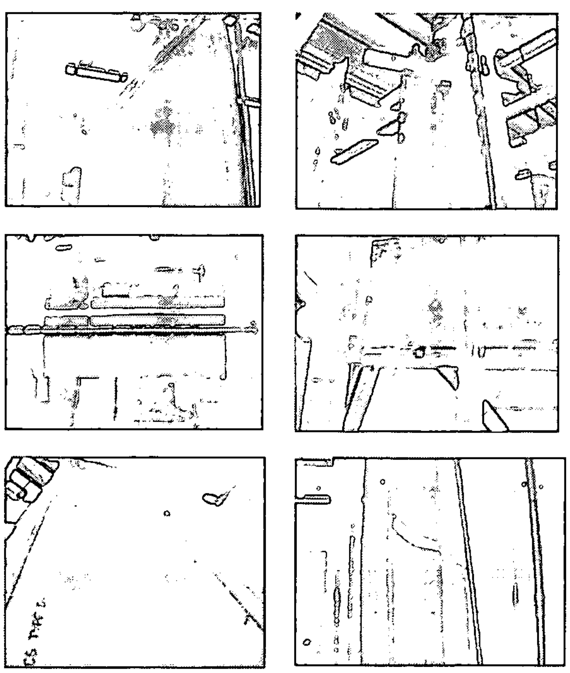


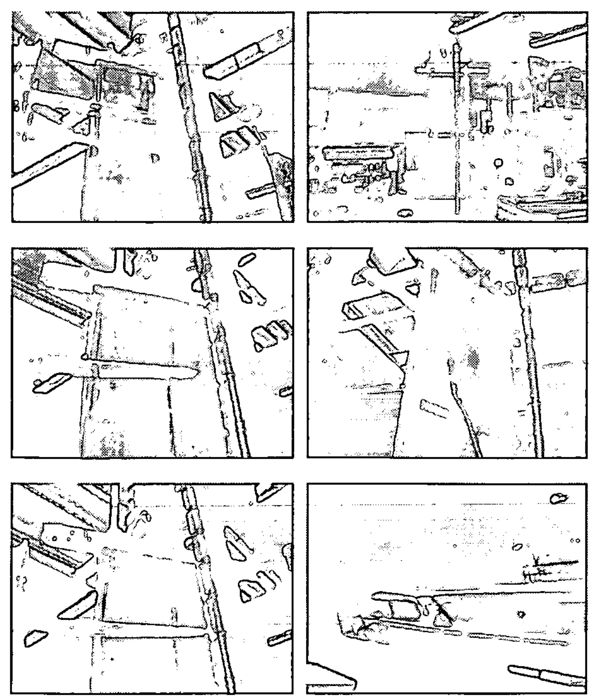
Figure A6. Missile Impact Test Apparatus



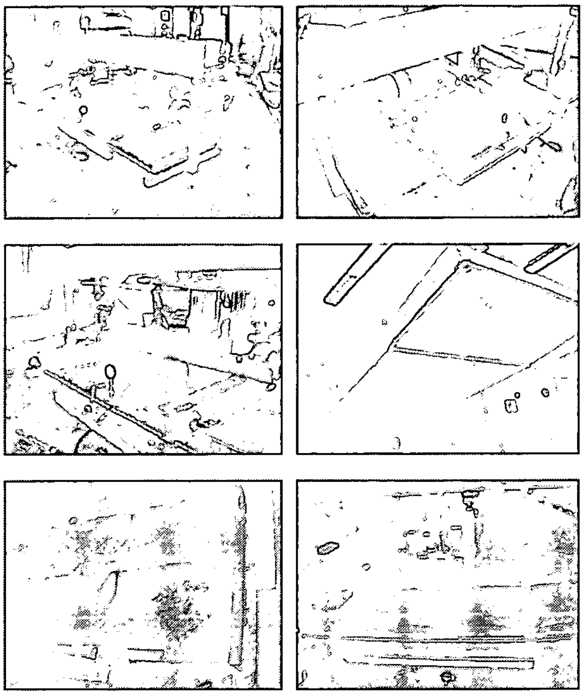
Appendix B
Test Photos



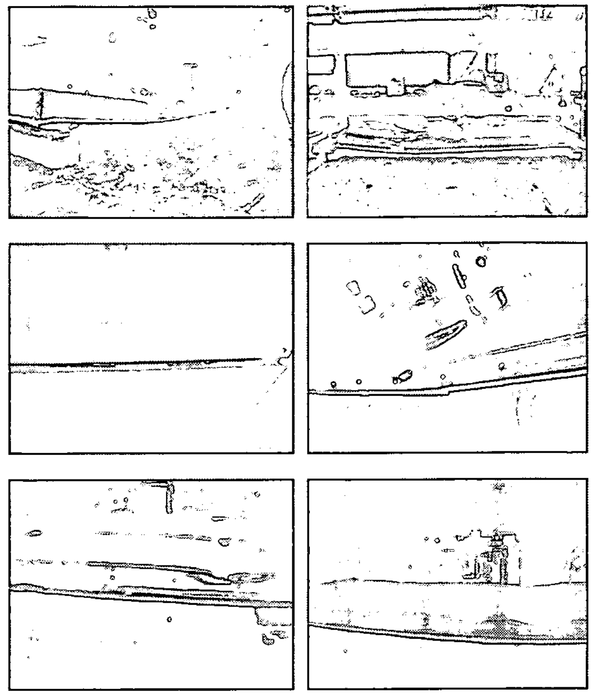
Panel Axial Tests Photos



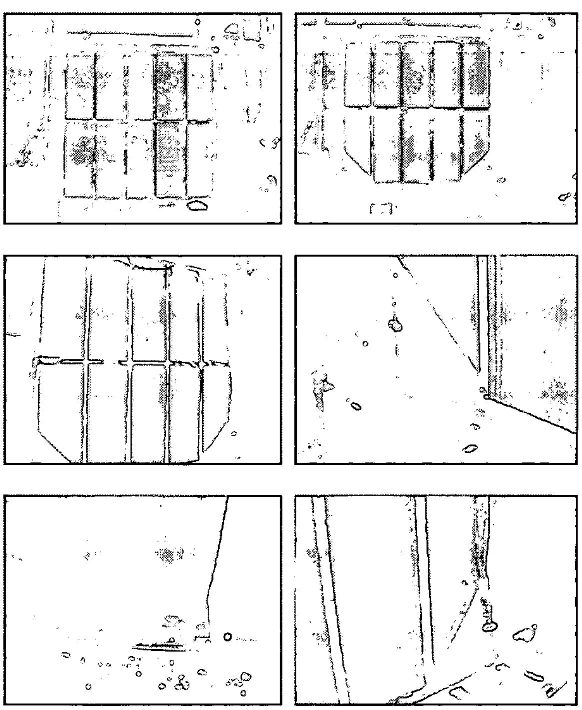
Panel Axial Tests Photos



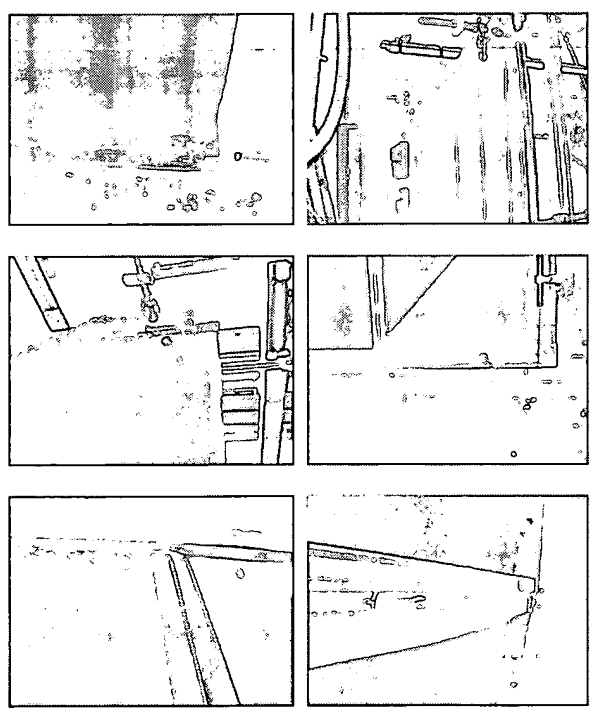
Panel Bending Tests Photos



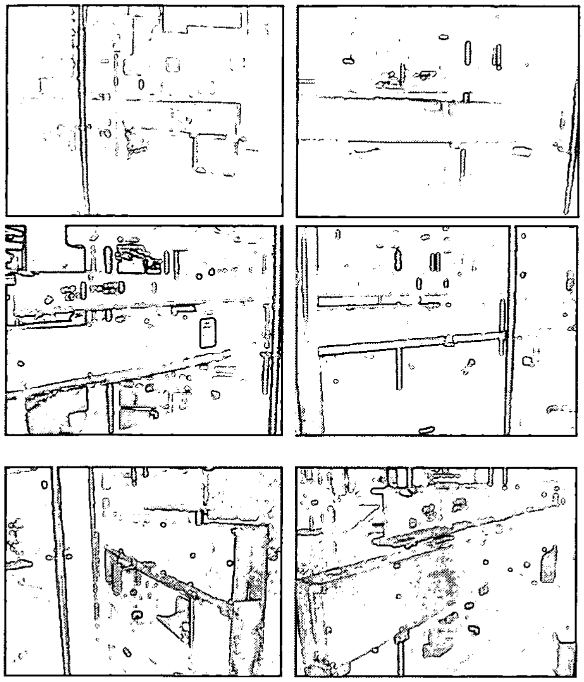
Panel Bending Tests Photos



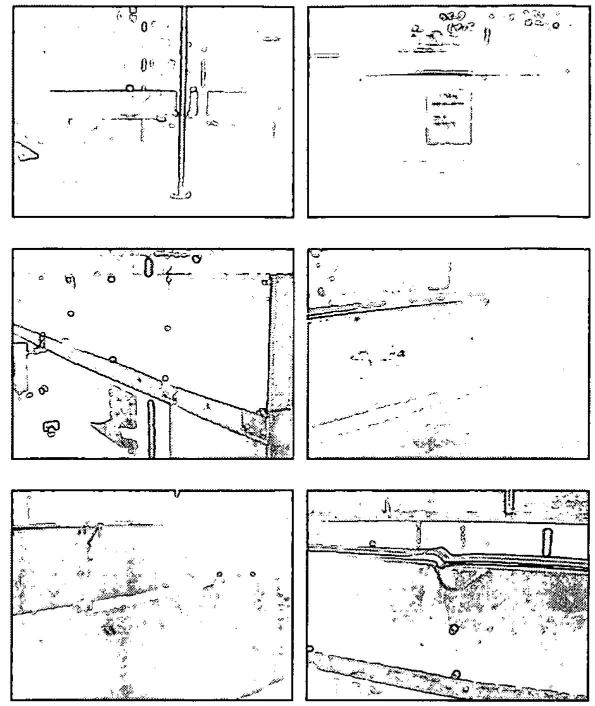
Panel Racking Shear Tests Photos



Panel Racking Shear Tests Photos

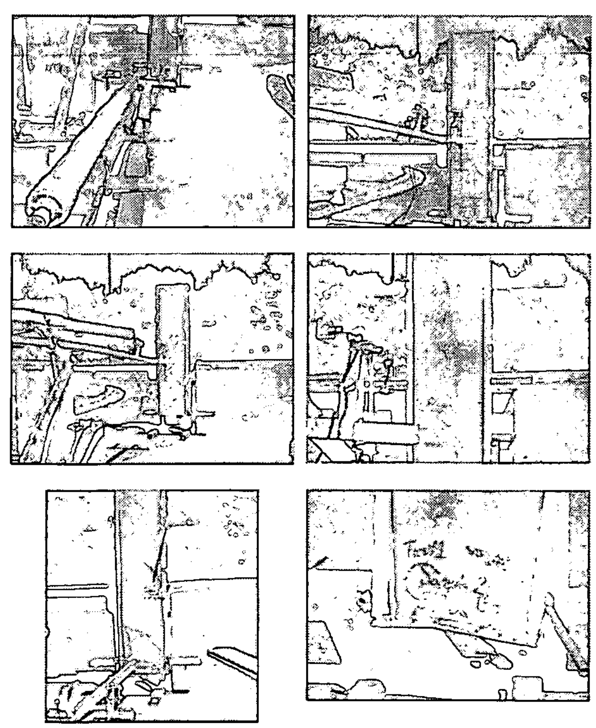


Header Test Photos



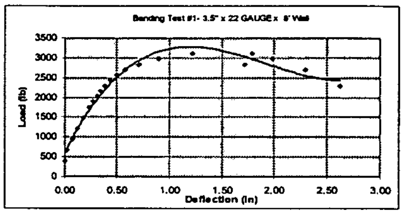
Header Test Photos

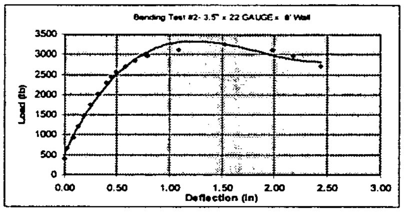
Track Tests Photos

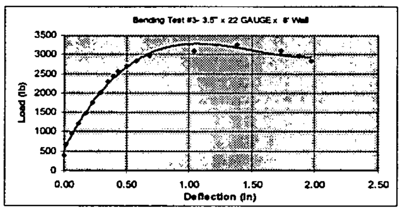


Missile Impact Tests Photos

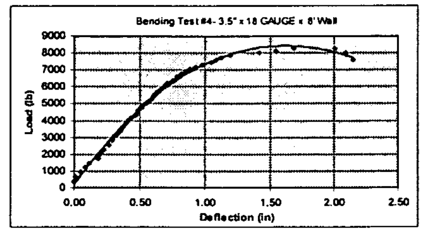
Appendix C
Selected Test Plots

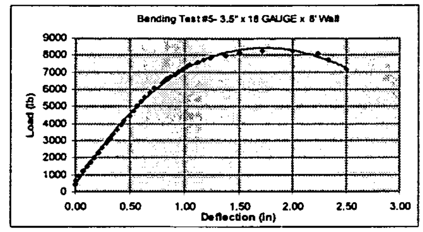


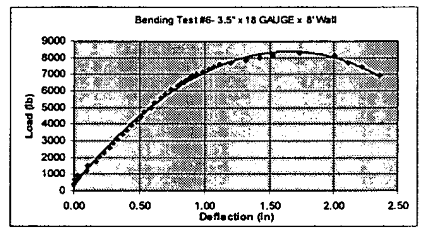




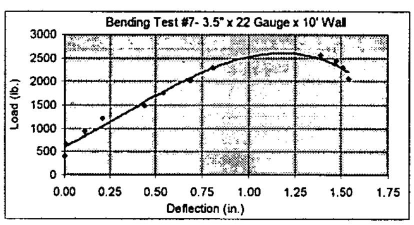
Panel Bending Test Plots

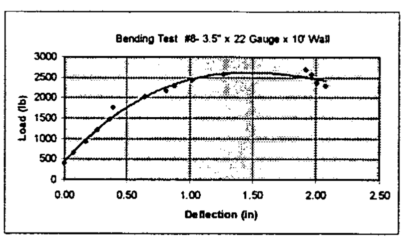


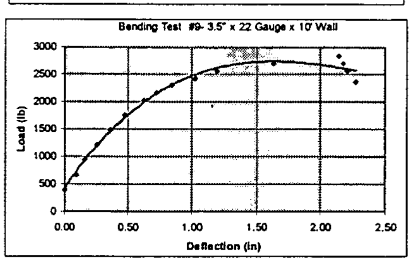




Panel Bending Test Plots







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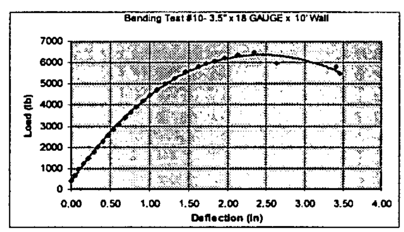

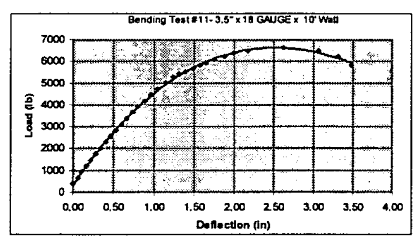

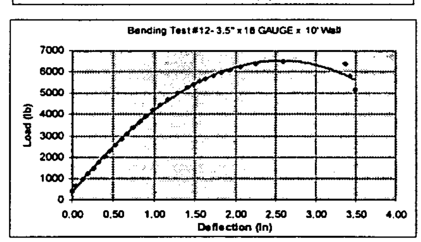

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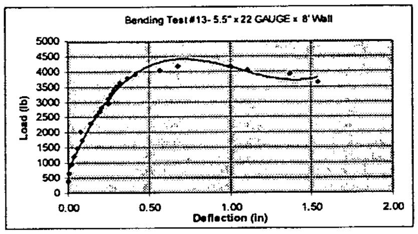

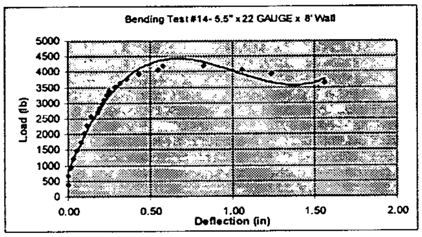

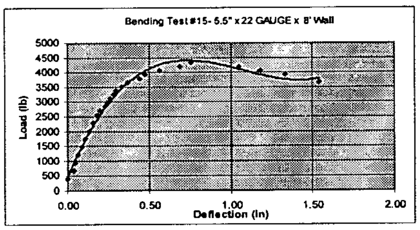

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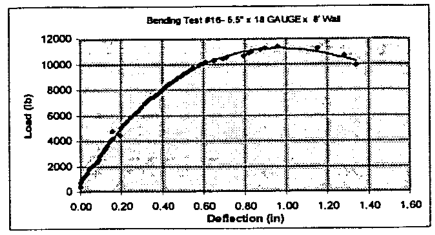

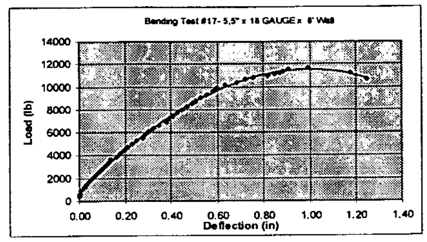

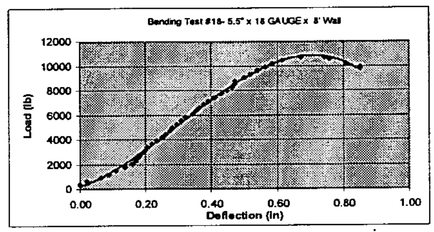

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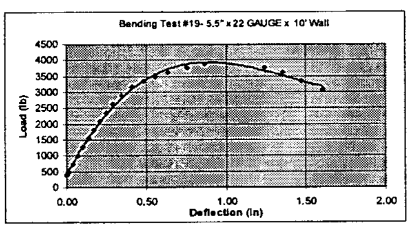

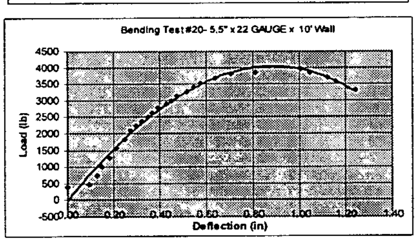

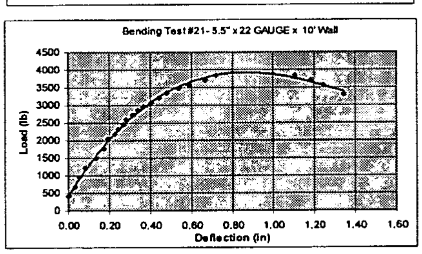

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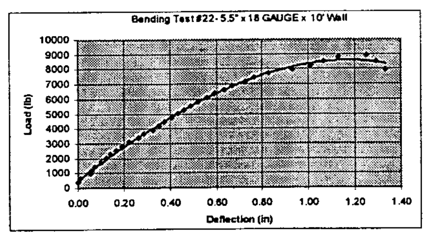

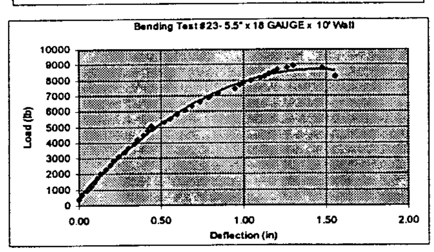

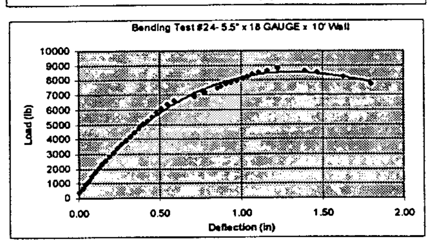

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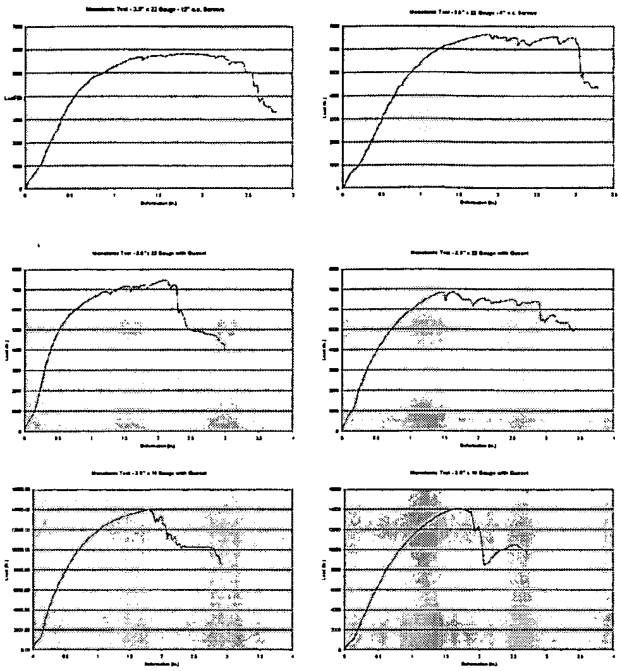

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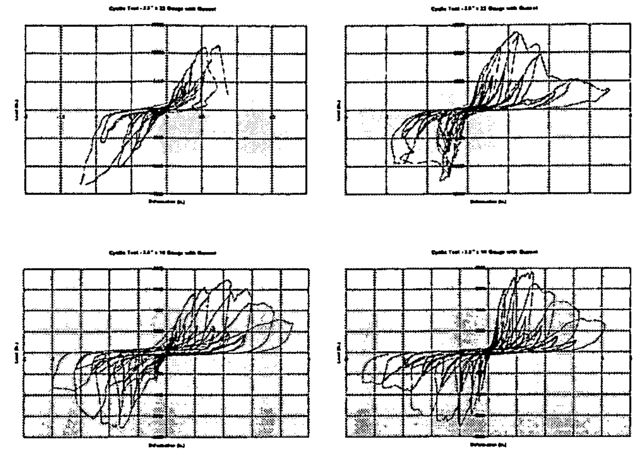
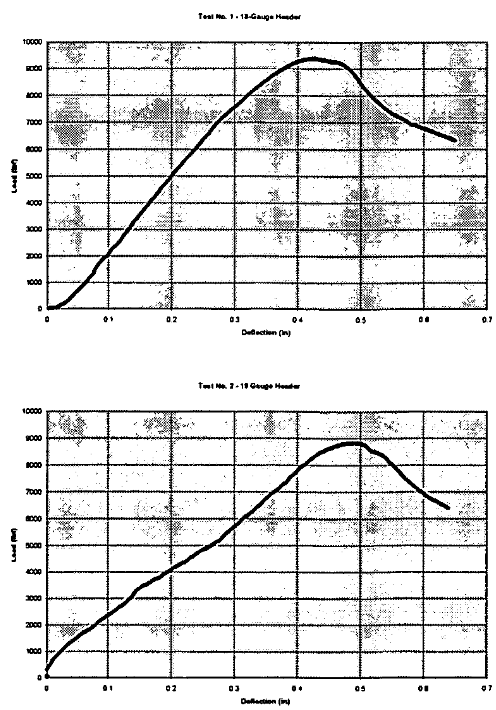
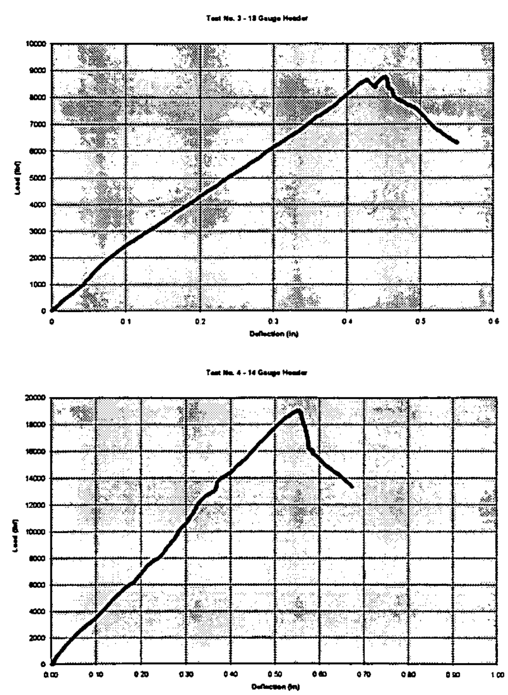


Panel Cyclic Shear Test Plots



Header Test Plots



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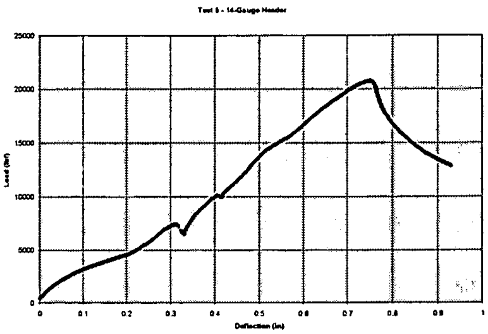

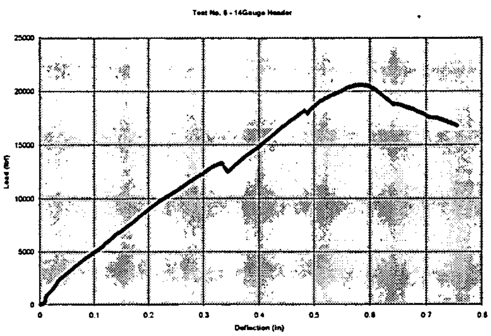

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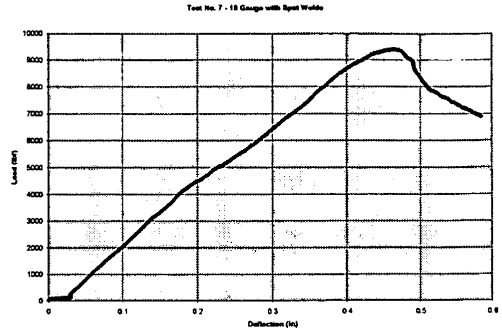

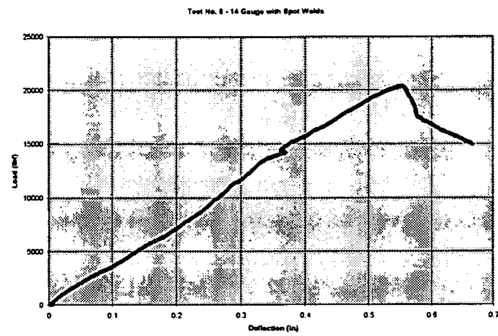

Header Test Plots